AP-S / URSI 2004 Monterey Conference
Short Course Abstracts

SC-1 (Full Day): The Art and Science of Ultra-Wideband Antenna Design (Hans Schantz, Q-Track)

The imminent wide scale commercial deployment of ultra-wideband (UWB) systems has led to increased interest in UWB antenna design. The requirements imposed by UWB systems place stringent demands on UWB antennas. For instance, the spectral and impedance matching properties of a UWB antenna exert a profound influence on an overall UWB system design. A well-designed UWB antenna can contribute to system performance by notching out undesired frequencies and controlling roll-off at the end of the operating bands. Thus UWB practice requires a holistic approach to system and antenna design.

Expanding on a well-received plenary address at the 2003 IEEE UWB Systems and Technologies Conference held November 17-19, 2003 in Reston, VA, this workshop provides a thorough overview of a timely topic by a leading expert in the field.

Course Outline

1. History of UWB Antennas
2. What is an Antenna
3. Basic Concepts
4. Transmission Lines
5. Antenna Taxonomy
6. UWB Propagation
7. Systems and Network Considerations
8. UWB Experimental Techniques

Dr. Hans Schantz is a consulting physicist and engineer specializing in time domain electromagnetics and high performance antennas, particularly ultra-wideband ones. From 1999 to 2002, Dr. Schantz was an antenna engineer at the Time Domain Corporation in Huntsville, Alabama where he was responsible for the development of Time Domains "BroadSpec™" line of small, highly efficient, planar ultra-wideband dipole antennas and many other innovative UWB antenna designs.

Dr. Schantz has published work in the American Journal of Physics and IEEE Antennas and Propagation Magazine. He has over a dozen conference papers, six US patents and several patent applications pending to his credit. Dr. Schantz is also Chief Scientist for The Q-Track Corporation, a start-up company that is developing near-field electromagnetic ranging technology.

SC-2 (Full Day): Spacebourne and Ground Antenna Design(William Imbriale, JPL))

Dr. Imbriale has recently published a book entitled Large Antennas of the Deep Space Network wherein he details the designs of large ground based antennas. Currently in work is a book on Spacebourne antennas. This daylong course will present the designs and technological innovations of many of JPL's space and ground antennas. Included will be a thorough treatment of all the analytical techniques used in design and performance assessment. Subjects to be covered include synthesis and analysis of reflector antennas, corrugated feed horn design, quasioptical analysis, dichroic reflectors, noise temperature estimation, beamwaveguide design, and microstrip patch antennas. Each design and analysis technique will be described along with specific examples of its use.

Each attendee will receive a CD that contains an electronic version of both books.

SC-3 (Full Day): Applications of IE3D in Designing Planar and 3D Antennas (Jian-X Zheng, Zeland)

This short course will focus on using the IE3D, a full-wave Method of Moments (MoM) simulator, for the design of planar and 3D antennas for wireless applications. It will start with a brief review of the schemes used in IE3D. Then, it will follow with practical examples on building geometry models and performing simulations for some typical structures. The course will also try to demonstrate how to use the tools efficiently for complicated and generalized structures. Finally, it will demonstrate how to make use of the powerful optimization capability to achieve specified antenna performances. The purposes of the short course are to let beginners to get familiar with modern EM tools and experienced users to get more skills to improve their efficiency in using the tools.

SC-4 (Full Day): A Maxwellian Approach to Smart Antennas (Tapan Sarkar, Syracuse Univ.))

Conventional approach in the electromagnetic community to adaptive antennas had employed analog processing techniques. With the advent of the digital technology the adaptive processing techniques used the conventional detection based methodology developed earlier for radar. The advantage of using the digital techniques is that one can cancel interferers in the main lobe. However, the detection-based methodology is difficult to implement in real time, as one needs to form a covariance matrix of the data. Also the effect of the finite size antenna and the mutual coupling between the antennas and their surroundings had so far been neglected. The result is that one needs to carry out calibration before any processing of the data can be done and it is an important aspect of the processing that needs to be done repeatedly. However, in a modern high speed data flow environment what is necessary is a new approach to adaptive processing which is based on estimation rather than on detection which had been the primary approach in radar where the shape of the received signal is assumed to be known and dispersion do not play an important role. However, in a rich multipath environment, a detection-based methodology is not the solution as we know there are many copies of the signal present and what we need to do is to estimate its correct value. In addition when an array operates in a near field environment it is not clear what antenna beam forming means as the antenna pattern can only be defined in the far-field! For an adaptive technique to operate in such complex dynamic electromagnetic environments we have proposed a Maxwellian approach to Adaptive Antenna [T. K. Sarkar, M. Wicks, M. Salazar-Palma and R. Bonneau, *Smart Antennas*, John Wiley & Sons, 2003]. The advantage of this approach is that it is quite amenable to a dynamic environment as we operate on a single snapshot of the data. It is rather important to note that for coherent interferers, the available degrees of freedom using a single snapshot of the data is identical to the conventional covariance based method of using multiple snapshots. In addition it is faster than the conventional methods by an order of magnitude and in addition no statistical knowledge of the clutter is necessary in the computation of this least squares solution. Accuracy and reliability of the new technique over conventional techniques will be demonstrated using real measured MCARM data set which was generated by an air borne phased array trying to detect targets in the land, urban and sea-clutter using space-time adaptive processing.

SC-5 (Full Day): Reflector Antenna Design and Development (Hans Henrik Viskum, Ticra))

The course will give an introduction to the design and analysis of single and dual reflector antennas, center-fed as well as offset. After a brief review of the analysis methods commonly employed for space- and earth-station reflector antennas, the basic design principles will be presented. First, the single and dual spot-beam antennas are considered, with the relationship between size, feed illumination and directivity and sidelobe levels. The influence of struts and subreflectors or feed blockage will be discussed. The origin of cross-polarization in offset designs will be addressed and it will be shown how to improve the polarization characteristics in single reflector systems by using polarization grids, and in dual reflectors by employing the compensation principles by Dragone and Mizuguchi.

The design of contoured-beam antennas for space application will be illustrated by a shaped reflector design, where surface shape is determined by optimizing a spline expansion until a desired radiation pattern over a prescribed coverage area is achieved. Important steps in the design phase will be emphasized, and the corrugated feed horn design principles will be briefly touched upon.

The lecture will be supported by PC presentations using the commercial codes GRASP8W and POS4. A number of the design and analysis principles can be examined by means of the student version of GRASP8W, which is available for free on the Internet.

SC-6 (Full Day): Theory and Applications of PBG Structures used as Artificial Magnetic Conductors and Soft and Hard Surfaces (Per-Simon Kildal, Chalmers University; Stefano Maci, University of Siena; Daniel F. Sievenpiper, HRL Laboratories)

In recent years there has been a lot of attention to using periodic structures in antenna design. These structures are nowadays referred to as photonic or electromagnetic bandgap structures or simply by their acronyms PBG or EBG structures. When such structures are used to obtain high-impedance surfaces, they are related to the transversely corrugated surface, that 15 years ago was generalized into a concept of soft and hard surfaces, based on a terminology used in acoustics and diffraction theory.

The course will relate the present PBG/EBG work to artificial magnetic conductors as well as to artificially soft and hard surfaces. The theory of ideal magnetic conductors and soft and hard surfaces will be explained in detail, as well as how to implement these theoretical models in existing software based on numerical methods such as GO, UTD, FDTD, FEM and moment method. We will also show how magnetic conductors and soft and hard surfaces can be realized artificially in practice, and how to analyze these realizations without having to model each detail of the periodic structure. This can be done by using unidirectional current grids, asymptotic boundary conditions for strip grids and corrugations, homogenized boundary conditions, or impedance boundary conditions. The limitations of the different analysis models as well as surface realizations will be discussed with particular attention to diffraction effects, dispersion, surface waves, leaky waves, and bandgap properties.

The work will be presented in relation to specific applications most of which have already been published in scientific journals. Examples of applications are: ground planes, low-profile antennas, reduction of coupling, removal of parallel-plate noise in multilayer circuit boards, reduction of far out sidelobes, antenna gain enhancement, effective waveguide apertures, quasi-TEM waveguides, compact horn antennas, reduction of blockage from cylindrical objects, grid amplifiers, and infinite array simulators (realized in rectangular waveguide) for broadside radiation and dual polarization. The course will also cover related tunable surfaces used for beam steering and adaptive antennas.

Copies of presentation slides and journal articles will be provided in electronic form.

SC-7 (Full Day): Advanced Computational Methods for Solving Large Electromagnetic Problems (J-F. Lee, Ohio State; John Volakis, University of Michigan)

This short course will introduce students into several recent advanced numerical methods for analyzing large electromagnetic scattering, radiation, and array problems. Particularly, our focus will be on efficient domain decomposition methods and fast integral equation methods. The first part of the short course will discussing in some detail the powerful Schwarz domain decomposition method. It will be shown that a special version of the Schwarz method, a non-overlapping Schwarz method, can be employed to derive a hybrid FEM and integral equation method. In this way, a very straightforward preconditioner can be developed simply from the knowledge of domain decomposition community. In this regard, fast integral equation methods such as Adaptive-Cross-Approximation (ACA) method, fast IE-FFT method, and multilevel FMM method will be used to speed up the IE portion of the hybrid formulation. The second half of the short course will discuss in detail the newly developed optimal domain decomposition (ODD) method, the Mortar technique for non-conforming finite elements, and a finite element tearing and interconnecting (FETI) like algorithm for solving large Electromagnetic problems. The combination of the ODD+Mortar+FETI is an extremely powerful numerical procedure which solves EM problems that correspond to hundreds of millions unknowns. Applications include: radiation from large finite antenna arrays, RCS of large finite arrays, finite PBG structures, and antenna and platform couplings. There are four lectures in this short course:

1. Lecture 1: A new hybrid Finite Elements and Integral Equation formulation through the optimal domain decomposition (ODD). (Jin-Fa Lee) This lecture describes another way to formulate the hybrid FE-IE method. By formulating the hybrid method as a special case of non-overlap domain decomposition methods, the coupling between the FEM and the IE can be accomplished simply through the optimal transmission condition.
2. Lecture 2: Fast Integral Equation Methods. (Jin-Fa Lee & John Volakis) This lecture addresses the theory and application of various fast integral equation methods. We shall discuss the Adaptive-Cross-Approximation (ACA) method, which is Green’s function independent, and the multilevel FMM method. These fast integral equation methods can be employed to speed up the hybrid FEM+IE method introduced in Lecture 1 for open domain problems.
3. Lecture 3: Single building block of ODD+Mortar+FETI method. (Jin-Fa Lee) The ODD is a powerful PDE method for solving large problems. To circumvent the troublesome convergence issue in traditional DD methods for solving Helmholtz equations, the optimal DD method is introduced; The Mortar technique relaxes the requirements of mesh generation for domains and subsequently allowing non-conforming meshes across domain boundaries; and, finally, the FETI-like algorithm will transfer the solution domains from the primal finite element meshes to the dual boundary meshes on the domain. The single block ODD+Mortar+FETI procedure is extremely well suited to solve large finite antenna arrays and frequency selective surface problems. Large finite arrays, which corresponds to almost 1 billion unknowns, can be readily simulated on a single PC in just 12 CPU hours.
4. Lecture 4: Multiple building blocks ODD+Mortar+FETI algorithm. (Jin-Fa Lee) This lecture extends the capabilities of ODD+Mortar+FETI method to multiple building blocks. Of particular interests is the use of Mortar technique in the design optimization process. We shall address the method through various applications: large antenna arrays with radome, irregular ground planes etc, large finite PBG structures, and antennas and platform couplings. The attendees will see for the first time the unthinkable electromagnetic problems being solved efficiently and accurately.

SC-8 (Full Day): Computational Electromagnetics in Packaging, interconnects, and Printed Circuit Board Design (Omar Ramahi, University of Maryland)

The fundamental functions of electronic packages and printed circuit boards (PCBs) are: (1) to provide mechanical and thermal support, (2) to protect the chips and devices against environmental factors, (3) to guarantee the integrity of the signal as it propagates between devices, and (4) to guarantee sufficient and suitable channels for power distribution needed by devices. The first two objectives, while very critical, provide less design challenge than the objectives that pertain to electrical performance. As the clock frequency increases reaching and exceeding the 2GHz region, insuring proper electrical performance of packages and boards becomes a formidable task requiring the full power of computational electromagnetics. In the microwave frequency region, distributed inductance and capacitance become increasingly difficult to quantify; skin effect starts to adversely impact the signal strength, and the potential for electromagnetic interference increases markedly. Characterization of PCBs, packages and interconnects entails extracting the distributed capacitance and inductance of all connections that are encountered in the signal and power distribution paths. A successful and effective characterization would require knowledge of electrical performance parameters, design topology and material, and above all, effective and efficient use and application of computational electromagnetics.

In this short course, we first review signal propagation fundamentals and introduce the methodologies used for circuit parameters extraction. We discuss the available electromagnetic computational tools and address their effectiveness in parameter extraction of real-world boards and packages. We discuss the use of computational tools in assessing the electromagnetic interference potential of packages, boards and interconnects. Finally, we discuss current research trends in new algorithm development and new technologies.

SC-9 (Half Day): Advances in Electrically Small Antennas (Steven Best, AFRL)

Electrically small antennas represent one of the most challenging design problems for the antenna engineer. As electronic components and devices rapidly decrease in size, there is an increasing demand for physically smaller antennas. At some frequencies, the requirement for a physically small antenna does not necessarily translate into a requirement for an electrically small antenna. However, with decreasing physical size at any frequency, the design challenge increases because performance requirements are rarely relaxed.

This ½-day workshop provides a detailed discussion on the theory, challenges and performance trade-offs associated with the design of electrically small antennas. Additionally, many electrically small antenna designs are presented with a specific focus on recent advances made in this field.

The workshop begins with an overview of the basic theory and concepts associated with electrically small antennas. This segment of the presentation provides an understanding of antenna performance limitations in terms of impedance, radiation patterns, bandwidth, efficiency, and quality factor (Q). A new, generalized formulation for antenna Q is presented that is valid over a much wider range of impedance, frequency and bandwidth values than previous formulations.

The workshop continues with a detailed discussion of recent advances in the field of electrically small antenna design. Numerous techniques used to design self-resonant electrically small antennas are discussed. Techniques discussed include dielectric loading, impedance loading, linear loading (increasing wire length), top-loading, folded configurations, Genetic Algorithm optimization, etc. The resonant performance properties of numerous antenna configurations and types are presented and compared. The relationship between the antenna's performance characteristics and its physical properties are discussed. Issues such as the significance of antenna geometry and current vector alignment in establishing the resonant properties of an antenna are considered.

The workshop concludes with a discussion on recent advances in the design of low profile, conformal and integrated device antennas.

SC-10 (Half Day): Genetic Algorithms in Engineering Electromagnetics: Concepts, Implementations and Applications (Y. Rahmat-Samii, UCLA)

GA Concept: Since the early part of this decade, Evolutionary Optimization (EO) techniques have been applied with growing applications to the design of electromagnetic systems of increasing complexity. The recent popularity experienced by EO methods is not unique to the field of electromagnetics; in fact, EO techniques have been successfully applied to problems in fields ranging from engineering to economics and artificial intelligence. Among various EO's, Genetic Algorithms (GA) have attracted much attention. GA schemes are finding popularity in electromagnetics as design tools and problem solvers because of their versatility and ability to optimize in complex multimodal search spaces applied to non-differentiable cost functions.

GA Implementation: Relying on Darwin's original thoughts, it has been argued that life in this world in all its diverse and amazing forms was evolved by natural selection and natural adaptation processes controlled by the survivability of the fittest species. With this acceptance has come the temptation that perhaps one might be able to utilize nature's "selection and adaptation implementation engine" and apply it to the solution of engineering problems via the applications of Genetic Algorithms (GAs). In a few words, the machinery of Genetic Algorithms utilizes an optimization methodology that allows a global search of the cost surface via the mechanism of the statistical random processes dictated by the Darwinian evolutionary concept (Y. Rahmat-Samii and E. Michielssen, Electromagnetic Optimization by Genetic Algorithms, John Wiley, 1999). In this course, some of the key features of Genetic Algorithms are summarized in an innovative and illustrative fashion and then they are applied to facilitate the optimum design of a class of electromagnetic and antenna structures.

GA Applications: One of the aims of this course is to provide the participant with an up to date body of knowledge on the applications of GA techniques to the synthesis and optimization of electromagnetic systems. Specifically, this course will focus on: (a) engineering introduction to Genetic Algorithms by reviewing simple GAs and their standard terminology and operators (populations, parents, children, chromosome, selection, crossover, and mutation), (b) demonstration of the potential application of GAs to a variety of electromagnetic engineering designs including microstrip antennas, multi-band and wideband antennas, synthesis of non-planar radar absorbing materials for RCS applications, Luneburg lens antenna design, array antennas, synthesis of reflector and horn antennas, design of electromagnetic bandgap structures, etc, and (c) assessment of the advantages and the limitations of the technique. (d) Recent concepts in utilizing Micro-GA, particle swarms and hybrid techniques will also be highlighted. (e) Additionally, a comparative study will also be performed between GA and a newly developed Particle Swarm Optimization technique.

Yahya Rahmat-Samii is the Chairman and a Professor of Electrical Engineering at the University of California, Los Angeles (UCLA). Before joining UCLA, he was a Senior Research Scientist at NASA's Jet Propulsion Laboratory/California Institute of Technology. Dr. Rahmat-Samii was the 1995 President of IEEE Antennas and Propagation Society and was appointed an IEEE Distinguished Lecturer and presented lectures internationally. Dr. Rahmat-Samii was elected as a Fellow of IEEE in 1985 and a Fellow of IAE in 1986 and also served as the Vice President of AMTA. Dr. Rahmat-Samii was the 1984 recipient of the prestigious Henry Booker Award of USNC/URSI. Dr. Rahmat-Samii has authored and co-authored over 500 technical journal articles and conference papers and has written 16 book chapters and two books entitled, Electromagnetic Optimization by Genetic Algorithms, and Impedance Boundary Conditions in Electromagnetics. He is also the holder of several patents. His research contributions cover a diverse area of electromagnetics, antennas, satellite and personal communications, advanced material, modern measurement techniques, numerical and optimization techniques, etc (visit http://www.ee.ucla.edu). Dr. Rahmat-Samii has received numerous awards, including the 1992 and 1995 Wheeler Best Application Prize Paper Award for his papers published in the IEEE Antennas and Propagation Transactions, 1999 University of Illinois ECE Distinguished Alumni Award, IEEE Third Millennium Medal, and AMTA'2000 Distinguished Achievement Award. In 2001, Rahmat-Samii was the recipient of the Honorary Doctorate in Physics from the University of Santiago de Compostela, Spain.

SC-11 (Half Day): Planar Antennas for Wireless Communications (Kin-Lu Wong, Nat. Sun Yat-Sen Univ.)

Planar antennas, including microstrip and printed antennas, metal-plate antennas, ceramic chip and dielectric resonator antennas, are generally flat in appearance and have a low profile. Such planar antennas have recently found great applications in mobile communication systems and wireless local area networks (WLANs). Many innovative planar antenna designs for related applications such as in the internal mobile phone antennas, base-station antennas, WLAN mobile-unit (laptops, tablet PCs, and PDAs) and access-point antennas, and the like have been reported recently. In addition, many significant advances in achieving compact and broadband operations for planar antennas have been published lately.

In this course, very recent developments in planar antennas for applications in mobile and WLAN communications will be addressed. The topics will include: (1) dual-band and multiband internal bar-type and folder-type mobile phone antennas (PIFAs and very-low-profile planar monopoles); (2) base-station antennas for cellular systems, including dual-band and/or dual-pol designs; (3) planar antennas capable of dual-band and/or diversity operations for WLAN mobile units, such as the laptops, tablet PCs, and PDAs; (4) planar antennas capable of dual-band operation, UWB (ultra-wideband) operation, broadband CP (circular polarization) radiation, omnidirectional radiation, diversity operation for in-building WLAN access points to be installed on ceilings, on walls or on desks; (5) ceramic chip antennas, dielectric resonator antennas, and some promising low-cost surface-mount antennas suitable for WLAN applications. More than 100 related planar antenna designs will be presented.

SC-12 (Half Day): Antenna Characterization in Multipath Environments Using Reverberation Chamber (Per-Simon Kildal, Chalmers University)

The reverberation chamber has for many years found application in the EMC area. Recently, we have shown that it with great advantage can be used also for antenna measurements as it simulates effectively a uniform multi-path propagation environment. The course will give the basic theory of reverberation chambers, and show how the chamber can used to measure radiation efficiency, free space radiation impedance, and diversity gain of antennas; total radiated power and receiver sensitivity of mobile phones and other wireless or mobile terminals (GSM, CDMA, DECT, Bluetooth, UMTS); and channel capacity of MIMO antenna systems. The chamber is the only known measurement instrument for measuring diversity gain and channel capacity; the alternative being to drive measurement instruments around in an actual urban environment. A major advantage with this new measurement method is that the measurements fast and easily can be performed when the antenna or phone is located in different talk positions relative to a head phantom or other environments. Reverberation chambers for EMC applications are normally very large, but we will show that for measurements at 900 MHz and above it is possible to use a small chamber that can pass through a 80 cm wide door. This small chamber will be shown and demonstrated as part of the course.

The course is based on recent both published and unpublished material related to extensive measurements in both large and small reverberation chambers. The course will include discussion of results measured on actual mobile phones and Bluetooth modules.

Copies of slide presentations and journal articles will be provided in electronic format.

The reverberation chamber with antenna measurement procedures have been commercialized by the company Bluetest AB (www.bluetest.se)

SC-13 (Half Day): Phased Arrays and Multibeam Antennas for Wireless (Christos Christodoulou, Univ. of New Mexico)

The "Wireless Revolution" of the late 90s generated enthusiasm, and consumed a significant amount of funds, only suddenly disappear from the industry radar screen. The transfer of well-established military technologies to the commercial market seemed to have only very little success.

This seminar talk will provide an overview of the current state of research in the area of multibeam antennas and describe how they can be used in wireless systems. A basic model for determining the angle of arrival (AOA) for incoming signals, the appropriate antenna beam-forming, and the adaptive algorithms that are currently used for array processing will be provided. Several antennas will be presented that cover the practical design aspects of incorporating such antennas in a wireless system. Moreover, it will be explained how these multibeam antennas, with spatial processing, can provide substantial additional improvement in the capacity and coverage.

The course consists of two parts:

Part I

- Wireless Communication - Basic Concepts
- Antennas and Arrays for Fixed Wireless Systems
- Point-To-Point
- Point-to-Multipoint - non-cellular
- Multifaceted Arrays
- Quasi-Optical Arrays
- Point-to-Multipoint - cellular
- Analog Beamformers
- Conformal Arrays
- The Contribution of the Radiating Element in Enhancing Channel Capacity

Part II

- Smart Antennas - Basic Concepts
- Adaptive Arrays
- Digital Beamforming
- Multiple Access codes
- Diversity
- Co-Channel Interference
- Types of Smart Antennas
- Adaptive Array Strategy
- Signal Model
- Beamforming Schemes
- Null Steering Beamformers
- Neural Beamformers
- Appelbaum Arrays
- Digital Beamformers
- Adaptive Algorithms
- Direction of Arrival
- Least Squares Support Vector Machines for Direction of Arrival Estimation
- Machine Learning Basics
- MIMO= beamforming both at receiver and transmitter

WS-1 (Half Day Workshop): Practical Aspects of T/R Module Implementation for Phased Arrays (Jerry Aguirre, Kyocera)

This workshop will focus on the Transmit and/or Receive module driving the antennae elements for phased arrays. It is typical for many requirements, such as thermal, RF, size, isolation, and weight to converge on the design of the Tx or Rx module. The realization of these modules need to be engineered for the best overall performance. Several cases and approaches will be discussed, each with some unique aspect of design. An overall presentation will begin the discussion.

Topics such as RF simulations, Thermal simulations, material choices, size constraints, and even some glimpses into future devices such as GaN applications in T/R modules will be covered.

WS-2 (Full Day Workshop): Dynamically-linked Electromagnetic and Circuit Simulation Workshop (Lawrence Williams, Ansoft)

This full-day workshop offers presentations from leading experts on electromagnetic (EM) and circuit design using commercial 3D EM and circuit design tools, including HFSS™ and Ansoft Designer™. Attendees will learn very practical aspects for efficiently applying commercial EDA (Electronic Design Automation) tools to antennas, arrays and feed networks in addition to microwave and RF circuits. The objective of this workshop is to demonstrate the breadth and depth of antenna, array and feed network design that may be accomplished with commercial EDA tools. Although commercial tools cannot address all antenna design applications, the breadth of application to which commercial tools are currently applied is impressive.

The workshop begins with a discussion of state-of-the-art EM/Circuit co-design techniques that simultaneously apply both EM and circuit analyses. The workshop will progress with a discussion of defense and aerospace antenna and array designs that have applied commercial EDA tools. Further designs of commercial antenna and compliance applications will follow. The workshop will close with a review of how commercial EDA tools are applied for educational purposes and the benefits of doing so.

Featured speakers and their topics for discussion include:

Brad Brim of Ansoft will discuss the joint application of EM and circuit analyses to efficiently address antenna and general microwave design applications. Examples will include feed networks, matching networks and filters designed with a dynamically linked combination of HFSS and Ansoft Designer. The advantages of EM/Circuit co-design will be discussed.

Dr. Robert Eisenhart of Eisenhart and Associates will discuss the application of HFSS to a dual band common aperture antenna array. Two arrays of 256 elements each interlaced into a single aperture provide independent transmit and receive bands. Application of HFSS and Ansoft Designer to the design of multiple E-plane, ridged waveguide splitters used in the feed network will be discussed.

Amedeo Larussi of Raytheon will discuss microwave component, antenna and feed designs performed with various codes. Design and modeling of dual ridge waveguide impedance transformer with HFSS and Excel will be discussed as well as a reflector antenna feed design with HFSS and NECREFL codes. HFSS Modeling of an electrically large Luneberg lens with two orthogonal feed antennas will also be discussed.

SooLiam Ooi of Motorola will discuss the automated design of commercial handset antennas and the prediction of specific absorption rate (SAR) in the human body. The discussion will include application of parameterized antenna designs as well as parametric EM analysis setup, enabling non-experts to quickly and successfully design application specific handset antennas. The benefits of tunable, parametric antenna models will be demonstrated.

Professor Dejan Filipovic of University of Colorado in Boulder will discuss how they have developed microwave and RF focused courses to include the use of commercial EM and circuit design tools. The undergraduate and graduate level curriculum will be discussed and the objectives of including commercial design tools reviewed. Examples of student projects for both antenna and microwave circuit applications will be presented. The benefits to students and industry will be examined.